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Reneau

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[54] **BI-DIRECTIONAL SHOCK SENSOR EMPLOYING REED SWITCH**

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[51] **Int. Cl.**[6] **H01H 35/14**

[52] **U.S. Cl.** .... **200/61.45 M**

[58] **Field of Search** .... 73/1.37, 1.38, 73/514.01, 514.16, 514.38, 514.39; 200/61.45 R–61.45 M; 335/205–207

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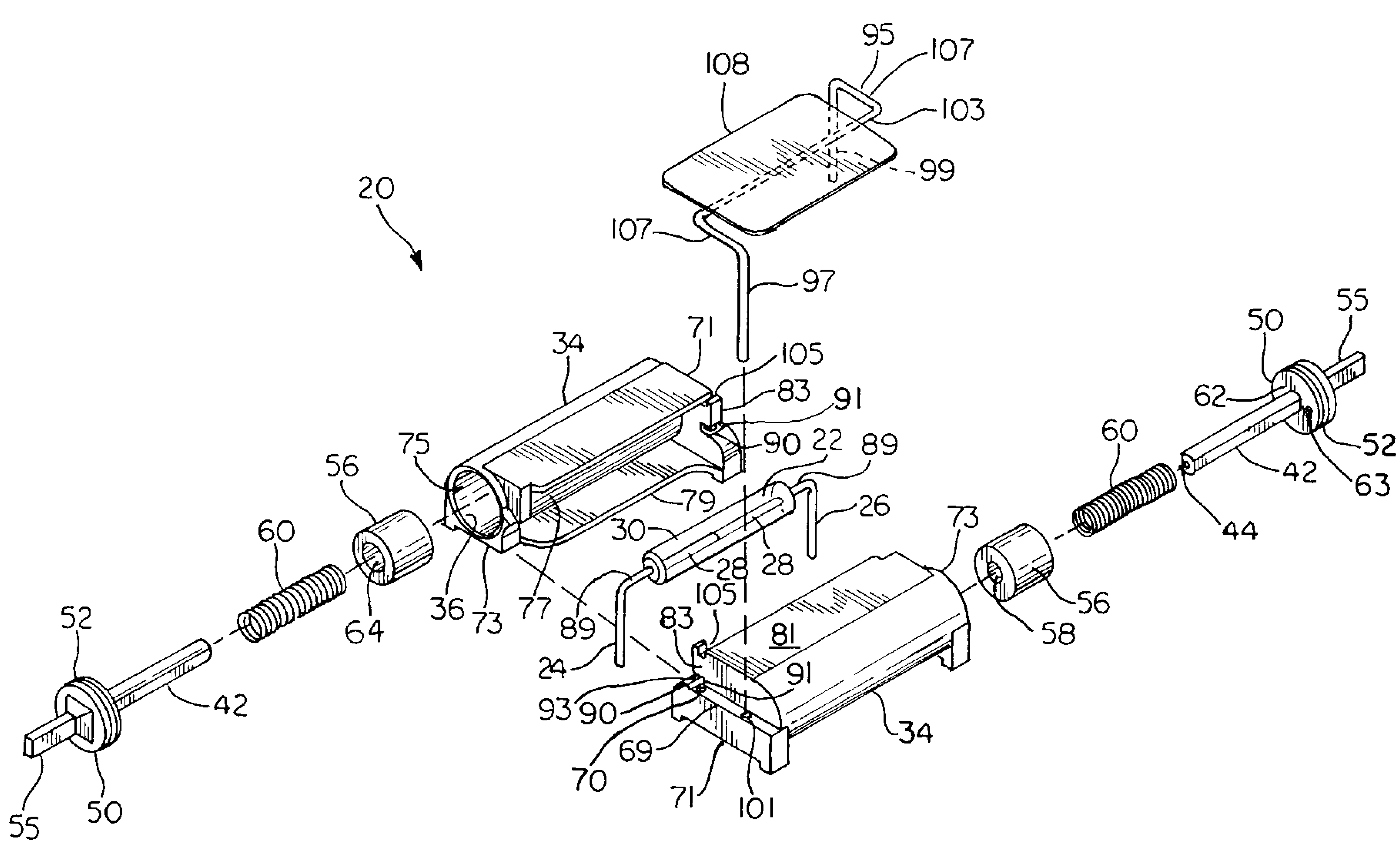
[57] **ABSTRACT**

A bidirectional shock sensor is constructed from a reed switch positioned between two shock sensing magnets. Each magnet is an annular ring which travels parallel to the reed switch reeds on a shaft spaced in a direction perpendicular to the axis of the reed switch. A spring pre-loads a first magnet against a first stop. A second spring pre-loads a second magnet against a second stop. The direction of travel of the first and second magnets is opposite and the first and second stops are positioned at opposite ends and on opposite sides of the reed switch. The magnets and the shafts on which they travel are positioned on identical housings which are arranged as mirror images with the reed switch positioned therebetween.

14 Claims, 3 Drawing Sheets



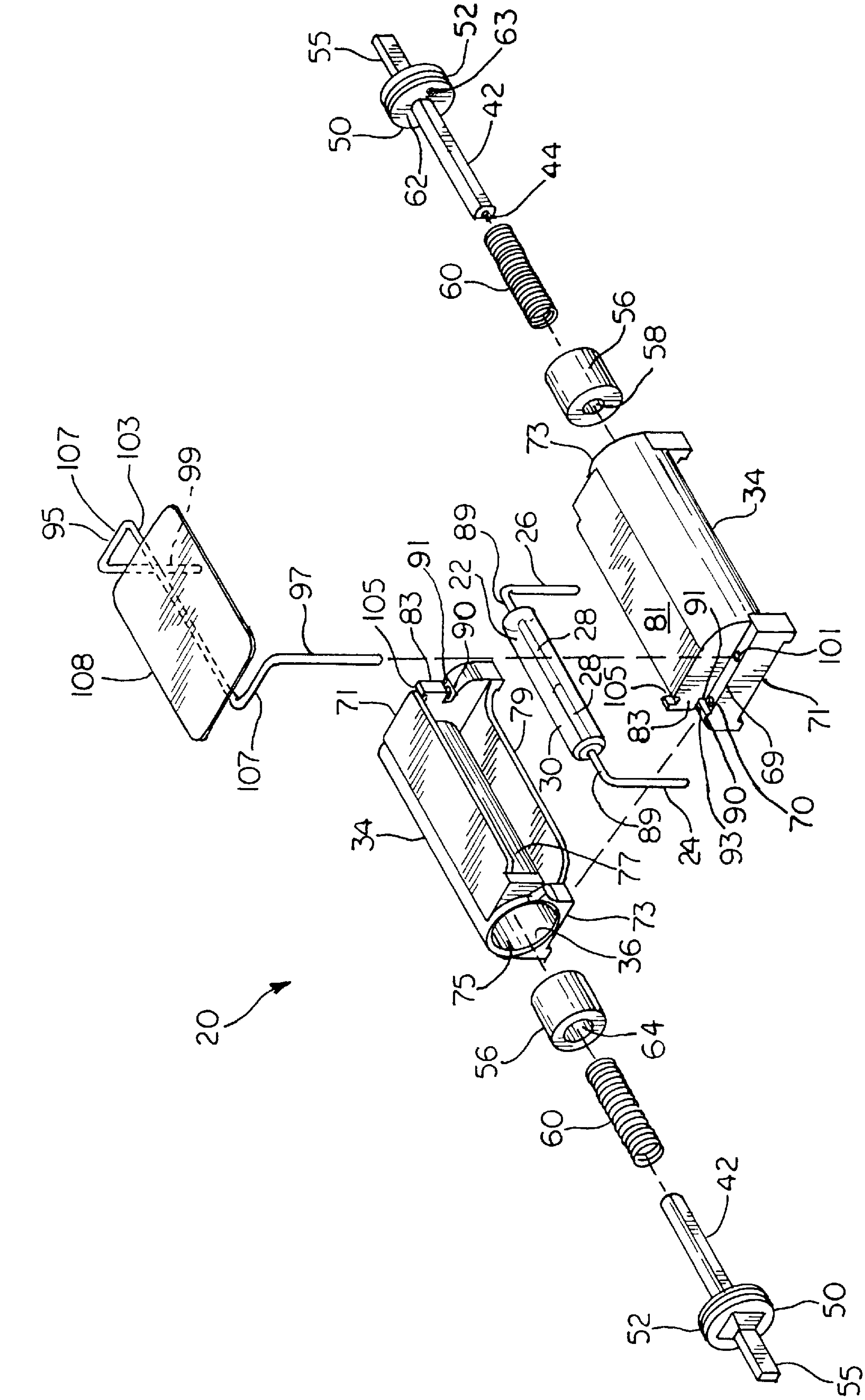

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FIG. 1

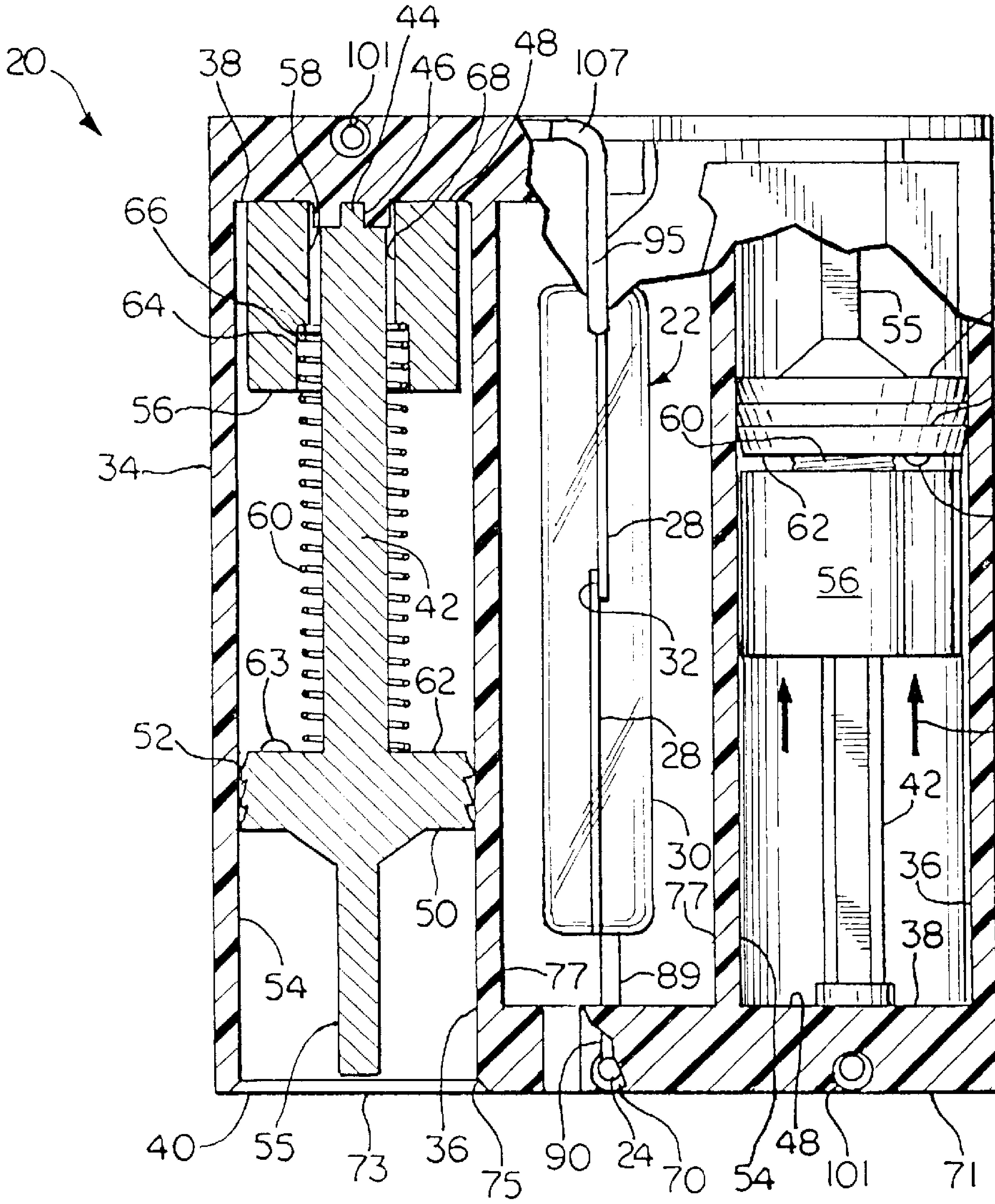
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FIG. 2

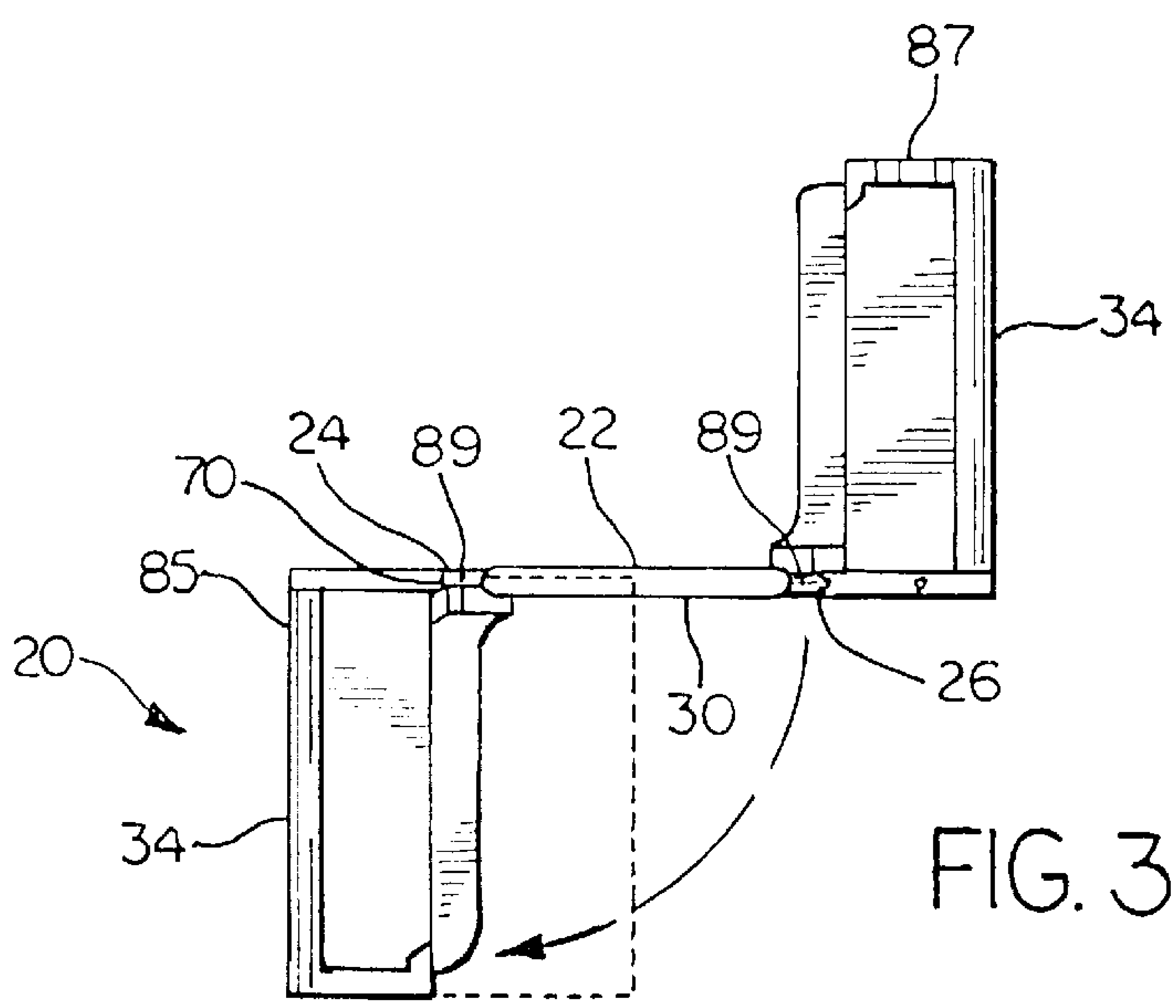
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FIG. 3

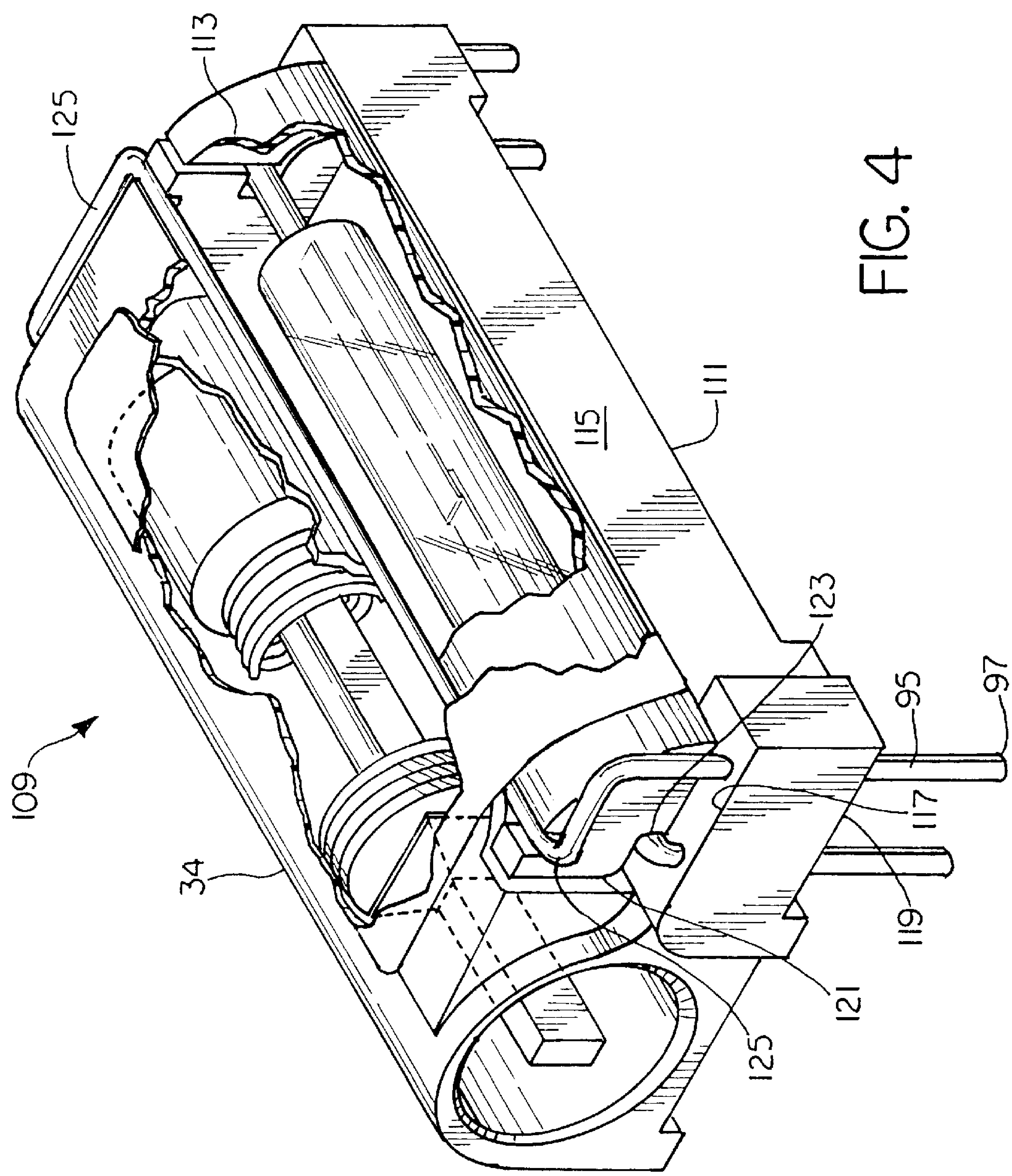

FIG. 4

BI-DIRECTIONAL SHOCK SENSOR EMPLOYING REED SWITCH

CROSS REFERENCES TO RELATED APPLICATIONS

STATEMENT AS TO RIGHTS TO INVENTIONS MADE UNDER FEDERALLY SPONSORED RESEARCH AND DEVELOPMENT

BACKGROUND OF THE INVENTION

present invention relates to shock sensors in general and shock sensors employing reed switches in particular.

Reed switches have found wide use in shock sensors, particularly as safing sensors in automobiles. Typically automobile crash sensing is performed by integrated micro device sensors which are incorporated onto chips which assess the magnitude and direction of the crash and employ preprogrammed logic to decide whether and how to deploy or activate various safety systems. These systems include air bags and seat belt retractors. Such micro sensors can be very cost-effectively incorporated into a safety system logic. However, such small scale devices are subject to electromagnetic interference and related phenomenon giving rise to possible false sensor outputs.

The need for a macro scale sensor arises to provide a safing sensor which provides the programmed logic with an indication that a crash of sufficient magnitude to warrant deployment of safety systems is in fact occurring. Shock sensors employing reed switches meet the need for a large scale device while at that the same time allowing a relatively small sized package which can be directly mounted onto a circuit board. A reed switch is resistant to electromagnetic interference and the hermetic seal formed by the glass capsule about the reeds results in a highly reliable switch which is sealed from the atmosphere. Thus, reed switch based shock sensors are usually the design choice for safing sensors forming part of a vehicle safety system.

Reed switch based shock sensors have been designed with multiple axes of sensitivity, yet such devices are typically considerably more expensive than unidirectional shock sensors or are more sensitive to large scale vibration. A typical reed switch based shock sensor has an acceleration sensing magnetic mass which is held against a stop by a spring. The spring is typically pre-loaded so that no motion of the sensing mass takes place unless the acceleration loads exceed a selected value. Obtaining pre-loaded sensing masses in a bidirectional shock sensor has proven problematic.

SUMMARY OF THE INVENTION

The bidirectional shock sensor of this invention employs a reed switch positioned between two shock sensing magnets. Each magnet is an annular ring which travels parallel to the reed switch reeds on a shaft positioned within a housing. A spring pre-loads a first magnet against a first stop. A second spring pre-loads a second magnet against a second stop. The direction of travel of the first and second magnets is opposite and the first and second stops are positioned at opposite ends and on opposite sides of the reed switch. The reed switch has staple formed leads, the first stable formed lead is inserted into a passageway in a first housing holding the first magnet. The second staple formed lead is inserted into a second housing holding the second magnet, the first and second housings are folded to enclose the reed switch and position the reed switch between the parallel shafts on which the shock sensing magnets ride. The housings may be identical and positioned with respect to each other as mirror images. The housings are held together by a wire strap which has the form of a staple which crosses the reed switch and, like the reed switch, the leads of the staple fit into passageways in the first and second housings. By diagonally crossing the reed switch, the strap locks the housings together in the collapsed position. A pressure-sensitive label or tape extends between the housings and holds the strap and the housings in place. When the shock sensor is soldered to a circuit board the reed switch and the strap are further fixed in place.

A single housing with a single magnet may form a unidirectional shock sensor with a reed switch cover which serves to lock the reed switch parallel to the single shaft on which a single, somewhat larger, shock sensing magnet is mounted.

It is a feature of the present invention to provide a shock sensor with bidirectional shock detection.

It is a further feature of the present invention to provide a shock sensor with cooperating magnetic elements.

It is another feature of the present invention to provide a bidirectional shock sensor with simplified assembly and alignment.

It is a still further feature of the present invention to provide a shock sensor which mounts directly on a circuit board, has a small footprint, and is low cost.

Further objects, features and advantages of the invention will be apparent from the following detailed description when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an exploded isometric view of the shock sensor of this invention.

FIG. **2** is a top plan view, part cut-away in section on multiple planes of the shock sensor of FIG. **1**, showing the sensor in a shock-responsive position.

FIG. **3** is a reduced scale illustrative top plan view showing the reed switch connecting in the two housing halves of the shock sensor of FIG. **1** in a uncollapsed positioned prior to the final assembly position shown in phantom view.

FIG. **4** is an isometric view, partially cut-away in section, of an alternative embodiment of the shock sensor of this invention providing unidirectional shock detection.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring more particularly to FIGS. **1–4**, wherein like numbers refer to similar parts, a shock sensor **20** is shown in FIGS. **1** and **2**. As shown in FIG. **1**, the shock sensor **20** has a single reed switch **22** which is disposed between two identical housings **34**, each of which contain a magnetic shock sensing mass which is disposed for sliding along axes parallel to the reed switch. The reed switch **22** has a first staple formed lead **24** at one end, and a second staple formed lead **26** at the other end. The leads **24**, **26** are connected to, and are actually co-formed with, ferromagnetic reeds **28** which are positioned within a glass capsule **30** which hermetically seals the reeds therewithin. The reeds **28** terminate at overlapping contact surfaces **32** which are spaced apart when the switch is in an unactivated condition, and which are brought into engagement in the presence of a magnetic field which causes the reeds **28** to attract.

The housings **34** are preferably identical injection molded plastic parts, one positioned on either side of the reed switch

22. Each housing **34** defines a cylindrical cavity **36** which has an axis which is generally parallel to the reed **28** in the assembled sensor **20**. As shown in FIG. **2**, each cavity **36** terminates at a blind end **38** opposite an open end **40**. A molded shaft **42** is positioned along the axis of each cylindrical cavity **36**. The shaft preferably has semicylindrical portions which are joined by parallel planar segments. Each shaft **42** has a protruding terminal key **44** which engages within a protruding annular keyway **46** which extends from the center of the surface **48** defining the blind end of the cavity **36**. The engagement of the shaft key **44** within the keyway **46** serves to position the shaft **42** along the axis of the cylindrical cavity **36**.

Each shaft **42** extends from a generally cylindrical disk **50**, the disk may be composed of an array of frustoconical barbs **52** which deform when inserted into the cylindrical cavity **36** to engage the cylindrical wall **54** of the cavity. A gripping extension **55** extends outwardly from each disk **50**. The gripping extensions **55** allow the shafts to be mechanically held and positioned. Although the disks **50** and the attached shafts **42** may be held in place by potting around the gripping extensions **55**, the frustoconical barbs **52** alone may be sufficient to lock the disks **50** in place.

A generally annular or ring-shaped magnet **56** having a central opening **58** is positioned about each shaft **42**. A spring **60** extends between each magnet **56** and an inner face **62** of the disk **50**, thereby biasing the magnet **56** against the surface **48** which forms the blind end **38** of the cylindrical cavity **36**. A small protrusion **63** or nubbin extends toward the blind end **38** from the inner face **62** of the disk **50**. The small protrusion **63** serves to reduce bounce from the inner face **62** when the magnet **56** collides with the face **62** due to a crash shock. By causing magnet to cock to one side, the protrusion **63** causes an engagement between the magnet **56** and the shaft **42** which dissipates energy, thus reducing bounce and increasing the switch dwell time.

Each magnet **56** has an enlarged portion **64** of the central opening **58** which accommodates the spring **60** between the shaft and the magnet **56**. The spring **60** is retained against the magnet **56** by a radially extending surface **66** which connects the enlarged portion **64** of the opening with a narrower portion **68** of the central opening **58**. Shaping of the magnet as described in my earlier U.S. Pat. No. 5,212,357, which is incorporated herein by reference, can also increase the dwell time.

The shock sensor **20** achieves bidirectional shock sensing with two mechanically independent sensing masses **56**. Each magnetic sensing mass **56** is pre-loaded against a surface **48**, and thus is not subject to vibration-induced motion which does not exceed the pre-load. The sensing masses **56** do interact electro-mechanically through their action on the individual reeds **28**. When the sensing magnetic masses **56** are in their rest positions the magnetic field which they produce permeates the adjacent reeds **28**. This reduces the size of the magnet **56** needed to cause closure of the reed switch **22**. By reducing the size of the magnets **56** the entire package is reduced in size, thus lowering cost and improving packaging efficiency.

As shown in FIG. **2**, when the shock sensor experiences a front end crash, the magnet **56** has apparent motion towards the inner face **62** of the disk **50** as indicated by arrow **57**. In a front end crash, acceleration takes place in a direction from front to rear in the automobile. As the magnet **56** is unconstrained along an axis defined by the shaft **42**, except by the spring **60**, it is not accelerated to the same degree as the housing **34**. This produces the apparent motion of the magnet **56**, acting as an acceleration sensing mass, towards the site of the crash, thereby moving the magnet **56** against the abutment or stop formed by the surface **62**. Motion of the magnet **56** relative to the reed switch **22** causes the reeds **28** to attract causing closure of the reed switch **22**.

The housings **34** are arranged so that the magnets **56** contained in opposed housings are biased by the springs **60** against surfaces **48** or abutments on the housing which are diametrically opposed. Thus a forward crash as shown in FIG. **2** causes the right magnet to move towards the second surface **62**. A rear end crash will cause the left magnet to move towards the second surface **62**. Thus a shock sensor **20** having two directions of sensitivity one-hundred-and-eighty degrees apart is provided.

Simplicity, and experience with similar actuation mechanisms, seeing for example by earlier patents U.S. Pat. Nos. 5,416,293 and 5,194,706, provides assurance of functionality. The automobile industry typically looks for sensors with mechanical simplicity combined with low cost and ability to accommodate changes in design parameters. Design parameters are readily adjusted in the sensor **20** by varying the spring constant and the magnet size or type. Typically, the magnets for cost reasons will be formed of metal particles embedded in plastic. Nevertheless, cast or powder metallurgy produced magnets may be used.

Each housing **34** has a ledge **69**, as shown in FIG. **1**, which runs along a side **71** of the housing **34** opposite the side **73** in which the opening **75** to the cavity **36** is formed. The ledge **69** has a first hole **70** which extends vertically through the ledge and the housing. The first hole **70** is adjacent a reed switch accepting face **77** of the housing **34**. A lower shelf **79** extends from the lower portion of the face **77**. The lower shelf **79** adjoins and reinforces the side **71** of housing which contains the first hole **70**. An upper shelf **81** extends from the upper portion of the face **77** in spaced parallel relation to the lower shelf **79**. The upper shelf **81** reinforces a portion **83** of the side **71** which is stepped back from the ledge **69**.

As shown in FIG. **3**, two identical housings **34** are joined to form the shock sensor **20** by placing the first lead **24** of the staple formed reed switch **22** through a first hole **70** on a first housing **85**, and by placing the second lead **26** through a first hole **70** on a second housing **87**. The identical housings **85**, and **87** are brought into inverse mirror image engagement by pivoting the housings. As the reed switch **22** is brought into parallel engagement with the sides **77** of the housings **85, 87**, a portion **89** of each lead **24, 26** which extends horizontally from the reed switch glass capsule **30** is captured by a slot **91** which has a lower surface **90** coplanar with the ledge **69** and an upper surface **93** spaced from the lower surface **90** which positions the reed switch in the vertical plane thereby assuring repeatable positioning of the reed switch with respect to both housings **85, 87**.

A strap **95** having a first vertical lead **97** and a second vertical lead **99** extends across the reed switch **22**. The first vertical lead **97** is positioned in a second hole **101** in the ledge **69** of the first housing **85**. Similarly the second vertical lead **99** is positioned in a second hole **101** in the second housing **87**. The strap has a horizontal section **103** which extends over the reed switch **22** along an interface formed where the upper shelves **81** terminate. A notch **105** is formed in the portion **83** of the side **71** above the slot **91**. The notch **105** receives the horizontal section **103** of the strap **95**. Short transverse sections **107** connect the horizontal section **103** of the strap **95** to the vertical leads **97, 99**. Once pivoted into engagement with one another and connected with the strap **95**, the two housings **34** are held together by a pressure-sensitive adhesive label or piece of tape **108** which overlies the opposed upper shelves **81**. The label **108** holds the strap **95** and the housings **34** in position.

To be cost effective, a shock sensor must be designed for automatic assembly. The shock sensor **20** incorporates interlocking parts which can be assembled without bonding or potting. The label **108** does not require a narrowly controlled environment or time to cure, and is thus compatible with rapid automatic assembly. Tolerances are achieved through self alignment between the reed switch **22** and the housings **34**.

An alternative embodiment shock sensor **109**, shown in FIG. **4**, employs a single housing **34** together with a housing closure **111**. The closure **111** has an upper shelf **113** which is semicylindrical in shape, and which extends down to the body **115** of the closure **111**. The closure **111** has a ledge **117** similar to the ledge **69** formed on the housing **34**. The ledge **117** has a first hole to receive the second lead **26** on the reed switch **22**, the side **119** of the closure **111**, has a portion **121** which forms a reed switch positioning slot **123** and a strap positioning notch **125** similar to those on the housing **34**. Because only a single magnet is present it will typically need to produce a greater magnetic field than the same magnet used in the shock sensor **20**.

It should be understood that the springs **60** which are placed in the identical housings **34** could have differing spring constants which would allow tailoring of the sensitivity in one direction verses sensitivity in the opposite direction. If this technique was used, to prevent confusion two housings **34** having different appearances and keying features would be employed.

It should be understood that the shock sensors described herein are not limited to the use of identical housings arranged in mirror image but includes shock sensors wherein the housing on which the acceleration sensing masses and the reed switch are mounted may be a unitary whole or may be constructed from two or more separate housings which differ in various respects from each other.

It should be understood that wherein the reed switch is described normally open so that movement of the acceleration sensing magnetic mass causes the reed switch to close, movement of the acceleration sensing mass could be used to open a normally closed reed switch.

It is understood that the invention is not limited to the particular construction and arrangement of parts herein illustrated and described, but embraces such modified forms thereof as come within the scope of the following claims.

I claim:

1. A shock sensor comprising:

a housing;

a reed switch mounted on the housing, the reed switch having reeds which define an axis along which the reeds lie;

a first shaft mounted on the housing in spaced parallel relation to the reed switch axis;

portions of the housing defining a first surface perpendicular to the shaft terminating the shaft in a first direction;

portions of the housing defining a second surface perpendicular to the first shaft and spaced from the first surface, the second surface terminating the shaft in a second direction;

a first magnet which functions as an acceleration sensing mass, the first magnet being mounted about the first shaft and movable on the first shaft between the first surface and the second surface; and

a first spring extending about the first shaft, and extending between the second surface and the magnet to pre-load the magnet against the first surface, wherein a first acceleration causes the magnet to slide along the first shaft towards the second surface and cause actuation of the reed switch.

2. The shock sensor of claim **1** further comprising:

a second shaft mounted on the housing in spaced parallel relation to the axis defined by the reed switch;

portions of the housing defining a third surface which is perpendicular to the second shaft and terminating the second shaft in the second direction opposite the first direction;

portions of the housing defining a fourth surface perpendicular to the second shaft and spaced from the third surface, the fourth surface terminating the second shaft in the first direction;

a second magnet which functions as an acceleration sensing mass, the second magnet being mounted about the second shaft and movable on the second shaft between the third surface and the forth surface; and

a second spring positioned on the second shaft and extending between the fourth surface and the magnet to pre-load the magnet against the third surface, wherein a second acceleration force in a direction opposite from the first acceleration causes the magnet to slide along the shaft towards the fourth surface thus causes actuation of the reed switch.

3. The shock sensor of claim **2** wherein the housing is comprised of a first housing member and a second housing member, and wherein the first magnet is mounted to the first housing member and the second magnet is mounted to the second housing member, and wherein the reed switch is mounted to both the first housing member and the second housing member.

4. The shock sensor of claim **3** wherein the first housing member is substantially identical to the second housing member and the first housing member and the second housing member are arranged as mirror images with the reed switch positioned therebetween.

5. The shock sensor of claim **4** wherein the reed switch has a first staple formed lead and a second staple formed lead and wherein the first staple formed lead is linked to the first housing member, and the second staple formed lead is linked to the second housing member.

6. The shock sensor of claim **3** further comprising a metal strap which crosses over the reed switch and mechanically engages both the first housing member and the second housing member.

7. The shock sensor of claim **1** further comprising portions of the housing forming a cylindrical cavity having a cylindrical wall, the shaft extending along an axis defined by the cylindrical cavity, the magnet being movable on the shaft within the cylindrical cavity.

8. The shock sensor of claim **7** wherein the second surface is formed on a disk shaped portion of the housing which is formed integrally with the first shaft.

9. The shock sensor of claim **8** wherein the disk has circumferential generally conical barbs which engage with the cylindrical wall of the cylindrical cavity.

10. The shock sensor of claim **1** further comprising means for positioning the reed switch with respect to the shaft and the first and second surfaces.

11. A shock sensor of the type including a reed switch mounted to a housing, and a shock sensing magnetic mass biased by a spring to a first position where the reed switch is not activated and movable against the spring by acceleration to a second position where the reed switch is activated, the reed switch defining an axis, the improvement comprising:

a first shaft positioned parallel to and spaced from the reed switch in a direction perpendicular to the axis; and

portions of the magnet defining a central hole, wherein the shaft extends through the magnet central hole and the magnet is slidable on the shaft between a first position which does not actuate the reed switch, and a second position which actuates the reed switch.

12. The shock sensor of claim **11** further comprising:

a second shaft positioned parallel to the reed switch and the first shaft,

a second magnet having portions defining a central hole, the second shaft positioned within the hole and the second magnet slidable on the second shaft; and

a second spring biasing the second magnet to a position which does not actuate the reed switch, wherein the second magnet is slidable on the shaft in response to an acceleration force opposite in direction than the acceleration force which causes the first magnet to move along the first shaft.

13. An automotive shock sensor comprising:

a first housing;

a reed switch defining an axis and connected to the first housing;

a first shaft fixed to the first housing, the first shaft extending substantially parallel to the reed switch axis, and being spaced sidewardly from the reed switch;

a first magnet mounted on the shaft for movement along the shaft between a first abutment and a second abutment, the second abutment being directed toward the front of an automobile; and

a first spring positioned on the shaft between the first magnet and the second abutment, wherein the first spring biases the first magnet against the first abutment when the first housing is not subjected to an axial accelerative force, and wherein a front end collision drives the first magnet toward the second abutment to thereby actuate the reed switch.

14. The automotive shock sensor of claim **13** further comprising;

a second housing connected to the first housing, wherein the reed switch is positioned between the first housing and the second housing;

a second shaft connected to the second housing, the second shaft extending approximately parallel to the reed switch axis and spaced perpendicular to the axis;

a second magnet positioned on the second shaft for movement along the shaft between a second shaft first abutment and a second shaft second abutment, the second shaft second abutment being directed toward the rear of an automobile; and

a second spring positioned on the second shaft between the second magnet and the second shaft second abutment, wherein the second spring biases the second magnet against the second shaft first abutment when the second housing is not subjected to an axial accelerative force, and wherein a rear end collision drives the second magnet toward the second shaft second abutment to thereby actuate the reed switch.

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